ULTRA-LIGHTWEIGHT OPTICAL COLLECTOR USING IN-SPACE BUBBLE BLOWING AND METAL EVAPORATION TECHNOLOGIES

Final Report

JPL Task 1038

Yu Wang, (Section 387)

A. OBJECTIVES

An ultra-lightweight optical collector is very desirable for NASA's space missions. A collector can concentrate light to reduce the size of a spacecraft's solar cell panels, can be used for a big-aperture space telescope to acquire high resolution images, and can be used for big-diameter antennas to increase sensitivity and lower required power.

This task was aimed at studying the feasibility of a lightweight optical collector using in-space bubble blowing and metal evaporation technologies.

B. PROGRESS AND RESULTS

When we blow a soap bubble on earth, the soap bubble forms a very light sphere. But the size of the bubble is limited due to gravity. If we blow a bubble in space, the bubble can have an almost perfectly spherical shape and can grow very big, because there is no gravity. And such a spherical film is just what we need for optical collectors. Because space is a vacuum environment, we can then deposit metal coatings upon the spherical film to make an optical collector.

If we blow a free bubble in space, the bubble will have a spherical shape. Theoretical calculations show that the shape of the free bubble would change by applying an electrical field. Depending on the strength of the surface tension and the electrical field, the shape of the bubble can be either an ellipsoid or an elliptic paraboloid. The elliptic paraboloid is more desirable for space telescopes.

Several bubbles were blown using UV-curable epoxy. The epoxy was mixed with a commercially available surfactant and UV-curing agent, and then heated to eliminate gas bubbles formed during mixing. A small bubble was formed in a dish and then transferred to a ring support and pressurized to increase its size. Once exposed to UV, the epoxy cured and half the bubble was removed, leaving a spherical segment ready for metallization. These bubbles were then put in a vacuum chamber with a vacuum of $1x10^{-5}$, and coated with silver coating using thermal evaporation. Early depositions showed a lot of wrinkles around the edges of the coated bubbles. They indicated that different thermal expansion of the epoxy and the ring support was the problem. Later we reduced the evaporation rate, the deposition temperature became lower, and a very smooth bubble light collector was fabricated (see figure below).

The bubble light collector has a diameter of about two inches. It shows a shiny smooth semi-spherical surface almost everywhere except around the edges. There are still some small wrinkles around the edges. In space, we don't need an edge support for the bubble. So if we blow a free bubble in space, we will be able to have a smooth bubble light collector without wrinkles.

To blow a bubble in space, we need to find the proper materials. The epoxy we used got boiled in vacuum, and it cannot be used in space. We have tried several materials, including liquid crystals, commercial glues, and several oils. Some of them could stay in vacuum more than 48 hours without noticeable evaporation loss. These materials can be used in a future bubble light collector.

C. SIGNIFICATION OF RESULTS

This task developed a prototype of a bubble light collector, a two-inch diameter bubble which was blown and deposited with silver coating. The bubble light collector showed a smooth surface.

The results indicate that this bubble light collector technology is feasible. This technology can be used as a light collector to reduce the size of solar cell panels and supply more electrical energy for a spacecraft, for big-aperture space telescopes to acquire high-resolution images, and for big-diameter antennas to increase the sensitivity and lower the required power.

D. FINANCIAL STATUS

The total funding for this task was $30,000, all of which has been expended.

E. PERSONNEL

Experimental work was done with the cooperation of Jennifer Dooley, Mark Dragovan, and Wally Scrivens.

F. PUBLICATIONS

A NTR was filed (NPO-30649), and will be published in *NASA Tech. Brief.*